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L'auteur rend compte d'une recherche qui a pour objectif d'étudier l'approche collaborative dans la recherche en éducation. Pour ce faire, on étudie d'abord le concept de "collaboration". Puis on décrit un projet qui a utilisé l'approche collaborative dans le but de développer une approche d'enseignement constructiviste en sciences. Le groupe de recherche était composé de trois enseignants et de trois chercheurs universitaires. Ce projet est basé sur la supposition que les relations de collaboration font partie intégrale de tout apprentissage, autant du côté de la formation professionnelle que du côté étudiant, et que l'utilisation de l'approche collaborative chez l'enseignant peut améliorer sa pratique et sa croissance professionnelle.

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A Constructivist Approach to the Learning of Science: Collaborative Research with Science Teachers

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A CONSTRUCTIVIST APPROACH TO THE LEARNING OF SCIENCE: COLLABORATIVE RESEARCH WITH SCIENCE TEACHERS

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The term collaboration has appeared with increasing frequency in the literature of educational research as well as in policy documents directed at educational practice. A cursory inspection of recent conference papers at world-wide educational conferences will show the extent to which this term has crept into the lexicon of educators. Given the diversity of situations and approaches that have been described as collaborative, it may be helpful to ascertain the extent to which there may be a set of common meanings associated with its useage and whether there are any general features that might characterize collaborative approaches to educational problems. The intent of this paper is to initiate such an examination, first by raising some general questions regarding the nature of collaboration and second, by revealing some of the meanings that have been attached to this term in an ongoing research project involving classroom teachers and university educators.

What are some of the factors that could account for this apparent interest in collaborative approaches in the education community? One of the interesting features in this regard is that the term has been so widely used by *both* the research community and the community of practitioners to describe approaches for conducting educational inquiry and improving teaching practice respectively. Are there any common features to these approaches? What implications might these approaches have for teacher education? These are some of the questions that this paper will address.

Let me begin by examining the ordinary language meaning for the term collaboration. One definition quite simply is "to work in conjunction with another or others; to co-operate" (Oxford English Dictionary). Clearly the notion of working together in a co-operative manner captures some of the spirit of its useage in educational settings. However, beyond this somewhat straightforward characteristic, the additional meanings that have been attached to the term are less clear. This ambiguity of meaning can be attributed to our general understanding that collaboration involves a working relationship between people for the purpose of reaching some agreed upon goal. As such, the many different contexts in which collaboration might occur, with the resultant differences in perceived purposes for collaboration, the varied forms of relationships between the participants, and potentially diverse goals, make it all but impossible to try and develop any general sets of meaning to apply to the term collaboration. This does not mean, however, that one should not try to clarify the associated meanings of the term *in particular settings* since becoming clear about what we wish to convey to others in using the term is critical. In this regard, I am in agreement with the position taken by a number of contemporary philosophers who argue that the meaning of terms which refer to relationships among humans are often deeply ingrained *in the practice of this activity* (cf. Hirst, 1983; Morawetz, 1978). Hence the claim being advanced is that the nature of specific collaborative relationships are best examined in terms of the unique *contexts* of those practices. It is for this reason that I am examining the nature of

collaborative relationships as exemplified in terms of our current research project, which has focused upon the improvement of instructional practices in science teaching. I will begin with a brief overview of this project and then go on to discuss some of the questions and issues raised above.

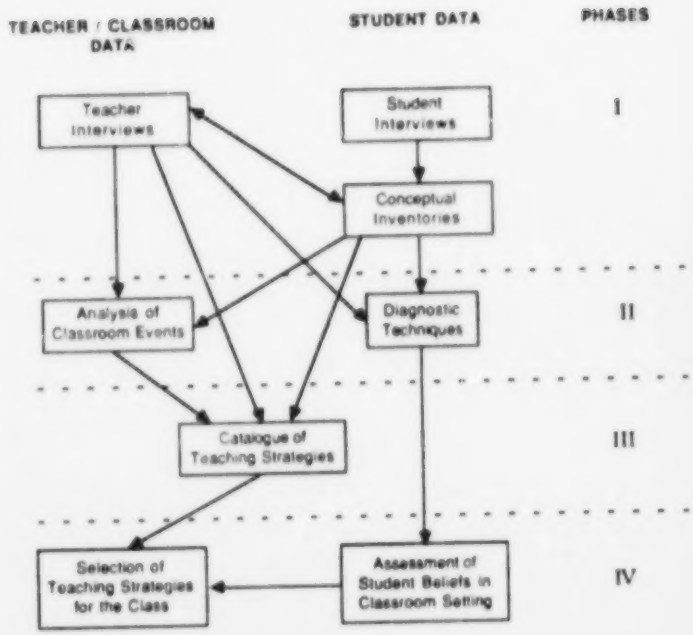
An Overview of the (SI)^2 Project

While the formal beginnings of our Students' Intuitions and Science Instruction group (i.e. the (SI)^2 Project) was initiated only five years ago, when we received funding from the Social Sciences and Humanities Research Council (Erickson, 1984), its conceptual and empirical roots can be traced back to a number of studies over the past twelve years that have been conducted at the Science Education Department at U.B.C. The nature of these studies consisted of two basic types. The first type was that of attempting to document and understand the nature of students' intuitions and thinking about a variety of concepts used to describe and explain physical and biological phenomena (e.g. heat and temperature, motion, forces, solution chemistry, inheritance, growth and cells). The second type endeavoured to examine some aspects of how students' intuitive knowledge might interact with classroom instruction. (See Erickson (1983) for a brief description of some of these studies). Obviously our group was not alone in exploring these problems. In fact, the area of student conceptions and the pedagogical implications of those conceptions has become one of the growth areas in science and mathematics education research. (See, for example, the papers at two recent international conferences held at Cornell University devoted entirely to these issues: Helm and Novak, 1983; Novak, 1987). In the early eighties, many researchers, including myself, were making conjectures about the value and even necessity of incorporating students' prior knowledge into classroom instruction. However, very few reports of systematic classroom practice incorporating this perspective has been published at the time (the exemplary work reported in many issues of the journal **Outlook**, edited by David Hawkins, and that of Minstrell (1984) in the U.S., Armstrong (1980) and Rowland (1984) in England, and Mitchell (1984) in Australia being notable exceptions). Thus we decided to address this complex problem area by developing a collaborative research team consisting of three classroom teachers and three university-based team members. This project had three broad aims:

(1) the establishment of a co-operative research group with practising teachers and university personnel;
(2) the development and documentation of a constructivist teaching perspective in conventional classroom settings;
(3) the development of strategies for communicating this perspective to pre-service and in-service teachers.

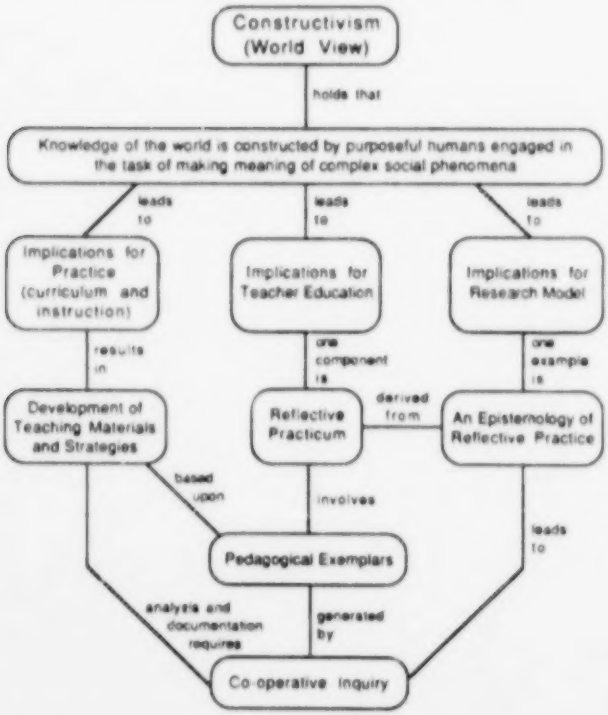
In an earlier paper (Erickson, 1988), I have indicated how this classroom-based project differed significantly from my earlier conception of how the research findings we were generating might be utilized by teachers. Suffice it to say that our present view of the research-practice interface is almost diametrically opposite to that which I, at least implicitly, held ten years ago. Instead of university researchers generating "diagnostic techniques" and "catalogues of teaching strategies" (as displayed in Figure 1) to be *implemented* by the classroom teacher, we now view the teacher as playing a much more

Figure 1
FLOWCHART OF PROJECT



fundamental role in the development phase itself. In fact, we go so far as to argue that to some extent each teacher must construct themselves a repertoire of such diagnostic and teaching strategies. This repertoire will, in turn, allow them to respond to the uniqueness and complexity of their practice setting. In claiming this, however, we are not suggesting that individual teachers cannot use or benefit from certain types of knowledge generated by researchers or, in particular, from *other teachers*. In fact our present project is based on the premise that we will be able to develop suitable descriptions of teaching practice that will provide opportunities for others, both novice and experienced teachers, to reflect upon their present understanding of teaching and learning so that they might come to "see classroom phenomena in a new way" (Erickson and MacKinnon, in press). An outline of our current "research agenda" is given in Figure 2. What I have endeavoured to portray in this schematic is the interdependence

Figure 2
OVERVIEW OF THE (si)³ RESEARCH AGENDA



of our research settings and our conceptual and methodological commitments. This settings include:

(1) the classrooms of our project teachers;
(2) the methods courses in our pre-service program;
(3) the practicum in our pre-service program.

Because it does illustrate certain of the principles of collaborative work that I will discuss later in this paper, I shall briefly outline the origins of the development of our project team.

The project was initiated early in the summer of 1985 by an intensive three day workshop and then followed up by a two day meeting at the end of the summer just before the new school term was to begin. The intended purpose of the initial workshop was to develop an overall plan for the project and lay out some specific objectives for work in the first year. In reality much of the time was spent by the six participants discussing readings that were distributed earlier as background papers on the topics of professional knowledge and collaborative inquiry, such as that outlined by Schön (1983), and what is meant both theoretically and pedagogically by a "constructivist" approach to science instruction. The discussions on these general perspectives of teaching and learning were frequently interspersed with many specific anecdotes by the teachers about students' actions in particular classroom situations. Interestingly enough, this particular form of discourse -- a dialectic between the theoretical and the practical if you will -- characterized many of the subsequent discussions held during regular project meetings.

I recall being somewhat concerned initially that we did not reach the objectives that I had in mind for the workshop. That is, we did not agree on a specific blueprint for action, nor was there much enthusiasm for developing detailed teaching strategies for the content areas that had been the subject of our earlier investigations into students' intuitive ideas. Nonetheless there was a feeling of optimism and excitement generated by the discussions -- particularly when they made contact with classroom incidents that all of the group members could identify with. Rather than focus of specific content units then, a consensus was reached that we would attempt to identify and document more generalized teaching strategies and descriptions of teaching practice that illustrated our constructivist perspective. It was thought that a teacher might be able to adapt these strategies to most content domains so as to identify student's common sense ideas and then "validate" these ideas by incorporating them in a fruitful way into the ongoing lesson sequence. A number of these general strategies were identified and documented -- some based upon the previous experiences of the group members, some based upon reports from the research literature (cf. Aguirre and Kuhn, 1988; Gurney, 1986; Kuhn and Aguirre, 1987; Parsons-Chatman and Sieben, 1988; and Sieben, 1987).

The first year of the project was spent with the teachers experimenting with different methods for identifying student ideas in a non-threatening manner and then evolving a number of different strategies for working with these ideas. The development of these strategies proceeded much like a cycle of inquiry in an action-research study (Carr and Kemmis, 1986). That is, the initial actions of the teacher created both desired and some undesirable behaviour on the part of the students. The strategy would subsequently be altered to achieve a more favourable balance between these two outcomes. The results of particular "trials" by one of the teachers were often discussed in the group meetings with the upshot frequently being some suggested follow-up activities. (In this instance the reflective component of the action-research cycle is carried out in a group setting rather than being an individual decision).

Over a period of a year, then, our group slowly learned to explain to each other the insights, the frustrations, the highlights of selected moments of practice. Accompanying these monthly project meetings were several more formal in-service sessions where the team would present to other teachers condensed versions of the teaching strategies that were being developed along with comments about the underlying constructivist perspective we had adopted. During these various informal and formal sessions, it

became clear that we were slowly evolving a common language to communicate this view initially to ourselves and subsequently to others. In retrospect, it seems to me that this time period of close to a year was necessary in order to negotiate among one another the unique personal meanings that underlie many of the terms that were used in these group meetings. At the beginning of the project, we shared many general ideas about what we saw as the most important outcomes (i.e. increased student understanding and what constituted the most preferred educational environment). Nonetheless, it is now clear that during the year considerable negotiation about the specific nature of these aims and methods was required among various group members. However, this negotiation process was rarely, if ever, explicit and it most frequently occurred when we engaged in discussions about particular classroom events. Thus we were slowly and quite unconsciously forging a set of shared commitments about how best to think and talk about the instances of classroom practice that the teachers in our group choose to discuss during our group meetings. Without realizing it, we were in effect implementing constructivist principles of learning as we engaged in the process of first, communicating our thoughts and actions to each other and second, to other educators who were not part of the project.

Any attempt to reconstruct either the dynamics or the substance of these interactions among the group members must remain just that -- a reconstruction. Nonetheless it seems reasonable to try to identify some of the significant features of the emerging consensus that has developed among the project team. In Figure 3, I have indentified these features in terms of a number of postulates that appeared to guide, in some way, the deliberations and the decisions made by the project team.

Figure 3
POSTULATES OF THE (SI)^2 PROGRAMME PERTAINING TO TEACHER DEVELOPMENT

1. We believe that the constructivist principles of learning that guide our approach to understanding student learning also applies to the learning of teaching.
2. We view it as important to integrate all components of professional development into a coherent research agenda.
3. Our view of professional knowledge is that it is under continual development and primarily oriented around the practice setting.
4. We believe that an effective method for communicating professional knowledge to teachers is through the use of pedagogical exemplars.
5. We believe it is important to encourage a disposition for "classroom-inquiry" in teachers and to create appropriate climates for this to occur.
6. We believe it will be necessary to develop a "language" of professional knowledge and classroom inquiry that will encourage open communication and criticism among educators.
7. We believe that a model of collaborative-inquiry is the best means for achieving our aims of professional growth and improved practice.

These postulates, then, form the conceptual and methodological bedrock of our project. I will only deal briefly with these postulates in this paper since they are discussed and illustrated in more detail in other papers by our group members (Aguirre and Kuhn, 1988; Erickson, 1987, 1988; Gurney, 1988, 1989; Kuhn and Aguirre, 1987; MacKinnon, 1988, 1989; Parsons-Chatman and Sirben, 1988; Sirben, 1987).

The first postulate declares our commitment to a constructivist perspective of learning as described, for instance, by Driver and Oldham (1986) and White (1988). Moreover, we submit that this perspective is equally relevant to our concerns about student learning of subject matter (the primary focus of the (SI)^2 Project) as it is to the learning of a complex practice such as teaching. For instance, my reference earlier to the extensive negotiation process engaged in by our group members, as they attached meaning to our discussions in terms of their respective experiences, illustrates for us the face validity of this postulate in the context of teaching practice.

The second and third postulates emerge, in part, from our constructivist perspective and address our view that professional knowledge is in a state of continual growth and change. Hence, we think that it is both important and informative to examine the nature of the problems of nurturing and enhancing the construction of knowledge at various stages and phases of professional development. Our concern for attempting to examine the issues and problems of professional growth in a coherent and integrated program is displayed in the schematic of our research agenda in Figure 2. As indicated in this Figure we have found Schön's writings on an "epistemology of reflective practice" to be both persuasive and fruitful in terms of the ways in which we conceptualize professional knowledge. While Schön's primary concern is to give an account of **how** a practitioner might construct practical knowledge in an action setting, his analysis of the numerous cases in his most recent writings on the subject (Schön, 1983, 1987, 1988) only reveals a rather generalized description of what this knowledge might look like in the context of teaching. We have begun to try and unpack some of the components of that knowledge base, or appreciative system as Schön calls it, in the more specific domain of science instruction (Erickson and MacKinnon, in press; MacKinnon and Erickson, 1988; Martin, 1988).

The technique, referred to in postulate four as "pedagogical exemplars", was developed for the purpose of attempting to communicate aspects of our constructivist perspective on science instruction to other teachers. We are currently examining its fruitfulness in the context of our teacher education programme. In brief, these exemplars consist of a series of videotaped excerpts of classroom episodes edited to illustrate particular features of some of the teaching strategies that our group has developed. Written materials and opportunities for discussion and reflection on these episodes will accompany these videotapes. (See Erickson (1987) for a discussion of the conceptual origins of this technique).

Postulate five outlines what we take to be a very basic disposition or stance that *ought* to characterize the practice of teaching through out a teachers' professional career. Again we are persuaded by Schön's description of how novice teachers construct an ever increasing and more powerful repertoire of teaching moves and skills. One of the primary constructs used by Schön to provide an interpretation of this construction process is his conception of "reflection". While part of this conception is captured by the ordinary meaning of the term, to pause and carefully consider the results of some action or situation (i.e. reflection-**on**-action), an equally important aspect is his emphasis upon reflection-**in**-action. This leads Schön to claim that an important component of teacher's knowledge **resides** in their actions in a practice setting. This claim is similar in nature to that made by other philosophers concerned with providing a description of

practical or professional knowledge (Morawetz, 1978, and Hirst, 1983). For instance Hirst puts the issue this way:

> For practical knowledge is not simply some blind unstructured executive competence that applies rules and principles .... Practical knowledge is acquired by living within the organised social world to which we belong, structured as it is by institutions and traditions of great variety (Hirst, 1983, p. 11-12, emphasis his).

One response to the enormous problem of nurturing continuing professional development, then requires an examination of the appropriate personal and institutional conditions for encouraging teachers to engage in this type of reflection (or "classroom inquiry" as we have called it) throughout their professional lives. It becomes very easy, once in possession of the necessary survival skills and a functional repertoire of teaching moves, to gradually shift teaching performances towards the aeronautical equivalent of an "autopilot".

The concern for developing an appropriate language that will nurture and support a professional culture of classroom inquiry, as indicated in postulate six, is a natural outgrowth of the preceding postulates. Given our experiences, under close to ideal circumstances, this task will be neither straightforward nor rapid. While there is clearly a growing interest in developing more of a professional ethos where teachers are recognized as one of the key actors on the educational stage (Lieberman, 1986; Feinmann-Nemser and Floden, 1986), the conceptual, organizational, and administrative problems in bringing about such a shift are immense.

The final postulate, which outlines our position that a variety of forms of collaborative inquiry will be necessary to achieve our aims, takes us to the primary subject of this paper. In looking back over the five years of the project, it now seems clear that the rationale used to justify our collaborative model of inquiry has shifted somewhat. In my initial application to the Social Sciences and Humanities Research Council for funding, I argued that teachers must be an integral part of the research team on primarily pragmatic grounds. A second, theoretically based argument was also advanced but not elaborated. Briefly stated, my original pragmatic arguments were that teachers must be actively involved in the project because they had direct access to the classrooms where the teaching strategies were to be field tested, they were in a better position than university researchers to judge whether the strategies were effective and functional, and finally they would have more credibility with their peers in terms of communicating our results to other teachers. The theoretical argument was based primarily upon Schön's analysis of reflective practice, which leads to a position that the development of pedagogically functional knowledge must be constructed in the practice setting.

While I think that both of these arguments in favour of a collaborative model of inquiry still stand, I am now inclined to argue that the theoretical argument is at least as compelling as the pragmatic one. As our group began to reflect upon some of the features that seemed to characterize our approach to classroom instruction, we gradually became aware of an internal consistency or coherence between the way that we thought about classroom experiences, about practicum experiences, and even the way that we interacted with each other. When these perceptions, which were noted by all of the group members in various contexts, were explicitly discussed, we attributed this convergence of thought to our commitment to a constructivist perspective (or "world view") of learning.

This perspective, which applies equally well to the grade nine student trying to understand algebra as it does to the teacher trying to understand the problems that students are experiencing in learning algebra, leads us to argue that the individual has the ultimate responsibility of constructing meaning out of the very complex learning environments in which they are located. However, the types of meaning that can be constructed to make sense out of these situations are powerfully constrained by a number of factors. Most notably these constraints come from their previous experiences and background knowledge, the conceptual richness of the linguistic community they are a member of, and in some instances of learning, the phenomena itself is constrained by the *reality* of our physical world. What our group has come to realize is that in order to extend the students' thinking and understanding about phenomena, such as static electricity, we had to be in a relationship with students such that we could better understand their existing ideas about the topic, how those ideas were influencing the meaning they were making of the classroom situation at that point in time, and finally to make instructional decisions about how best to proceed. In other words, we realized that we needed the students to collaborate with us as teachers, in much the same way as we endeavoured to establish a collaborative relationship between the teachers and university educators in the project itself.

Thus, this coherence that I referred to above comes from a shared set of beliefs and values about how people learn. Since all of the contexts in which we were operating -- instructional practices and professional development activities -- involved some aspect of learning, it would seem that these shared commitments about the nature of learning provided the continuity and structure we had implicitly noticed. Furthermore, I am arguing that collaborative relationships are an integral part of the learning environments that we have endeavoured to establish in those contexts involving student learning as well as teacher learning. Hence I am suggesting that collaborative relationships are to be encouraged at several different levels or educational contexts in which we have been operating. In the next section, I will explore the nature of collaborative relationships in some of these contexts and then examine some of the general principles that underlie these relationships in the latter section of this paper.

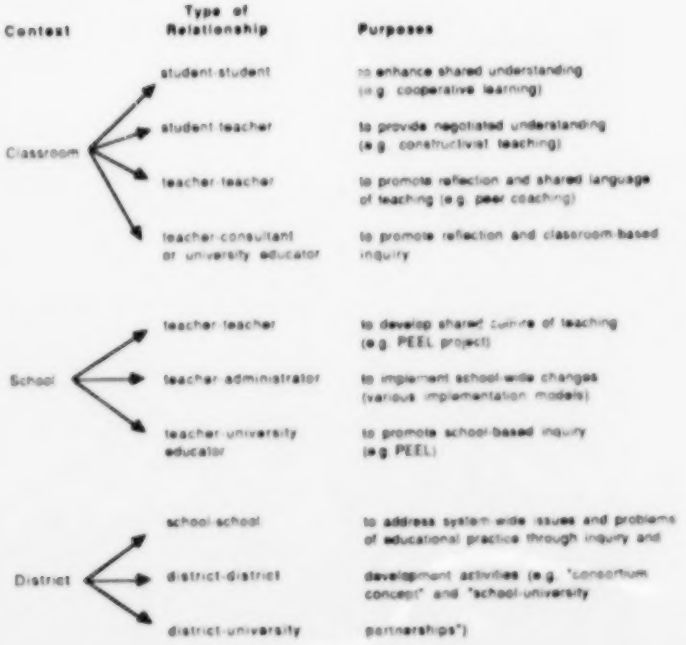
Contexts of Collaboration

There would seem to be three general, educational settings, or contexts where it seems to make sense to talk about collaborative relationships. These contexts and their associated relationships are presented in Figure 4.

The setting around which most of the work in our project has centered is the classroom. The primary relationship in this setting obviously is that between the teacher and the student. There were three other relationships that were also of concern to our project -- that of [student - student], [teacher - teacher], and of [teacher -university educator]. While there clearly could be other types of collaborative relationships in a given classroom, such as [principal - teacher], or [curriculum consultant - teacher], we have only mentioned those relationships that were exemplified in our project.

Because our project teachers were from different schools, we unfortunately were not able to move easily from classroom to school-level concerns. We do think that ultimately this transition from classroom concerns to school-level concerns is crucial

Figure 4
CONTEXTS AND PURPOSES OF COLLABORATIVE RELATIONSHIPS



in providing the necessary psychological, intellectual, and institutional resources in order to develop and sustain a climate of collaborative inquiry. While the literature on professional development contains many accounts of collaborative projects at the school level, there is one such project that comes very close to exemplifying at the school-level some of the principles that guide our work. This project, which was given the acronym of PEEL (Project to Enhance Effective Learning), orginally involved ten teachers in five different subject areas from a school in Melbourne. Fortunately they made the effort to document their efforts to collaborate with each other and with their pupils in the form of a book (Baird and Mitchell, 1987). Each of the teachers involved wrote straightforward yet eloquent, accounts of their efforts in encouraging their pupils to take more responsibility for their own learning. These chapters contain numerous accounts of the many problems faced by these teachers and their conjectures about

which of their actions were successful and which were not. As such, this book contains a wealth of information on the conditions which they judged to be essential in establishing and nurturing the collaborative culture which they managed to establish in their school. The basic philosophy and collaborative model for this project has subsequently been adapted by several other schools in the Melbourne area and the book is beginning to be cited extensively in the research literature on teacher development.

The final level at which one might nurture collaborative relationships is at a district level. Here one might observe efforts aimed at coordinating work at several schools in an endeavor, for instance, to introduce new curricular, instructional, or organizational policies. As above, the educational literature (in this case on implementation) is filled with reports of collaborative projects which have been implemented at the district level. One of the most interesting developments at this level is the series of school - university partnerships that are affiliated with the Center for Educational Renewal established by Goodlad and Sirotnik. In addition to publishing a book dealing with some of the practical, theoretical, and methodological issues of these partnerships (Sirotnik and Goodlad, 1987), they also distribute regular newsletters on recent developments and concerns in some of these partnerships. For the interested reader who wishes to pursue this model further I would recommend a closer examination of the Puget Sound Consortium directed by Anne Lieberman. This partnership has been in operation for several years, they have documented their activities, and Lieberman brings to the project many years of experience of collaborative work with teachers and school district personnel (Lieberman, 1988).

Principles of Collaboration

As I indicated in the introduction of this paper, I think that the diversity of contexts and purposes in which collaborative relationships might develop militates against the search for a set of common principles or values that would be shared by all projects. In particular, I think it is crucial in addressing this issue of underlying principles to identify the intended purpose for establishing a collaborative relationship for each of the partners. Hence, it should be clear that the following discussion refers to the types of collaborative relationships that we saw as important in the (SI)^2 Project as they related to a specific purpose.

We think that **one** of the underlying purposes of our project that was shared by all of the participants was that of *understanding and improving the learning process* as it was manifested in two areas -- student learning and teacher learning. While these two areas can be separated for the purpose of analysis, in our project they are totally interconnected, or nested, when they are examined in the classroom context. It should be emphasized that the various participants in the project have different purposes in understanding the learning process and clearly would express that understanding in terms of a different set of concepts. This difference in purpose in the understanding of learning, and the accompanying teaching practices intended to enhance it, along with the collaborative relationships that were part of our project to facilitate that understanding are given in Figure 5. In this scheme I have endeavoured to relate the types of understanding with these collaborative relationships and then illustrate what

Figure 5
"COLLABORATIVE INQUIRY IN THE (SI)^2 PROJECT"

we perceive to be the **primary** types of outcomes emanating from these relationships. While the terms public and private knowledge clearly require further elaboration, the only claim I wish to make at present is that **one** of the aims of university educators ought to be to make a public claim of their understanding of those teaching practices which enhance student learning. This is not to say that teachers or even students may not make public claims nor that university educators do not construct private meanings; rather I am suggesting that the most common purpose of students' or teachers' understanding is generally directed towards increasing their own private knowledge base.

In the context of our project, these three types of understanding should be thought of as being nested as illustrated below:

$$\left\{\begin{array}{l}\text{understanding of}\\ \text{teaching practice}\\ \text{by university}\\ \text{educator}\end{array}\right. \longleftrightarrow \left[\begin{array}{l}\text{understanding of}\\ \text{teaching practice}\\ \text{by teacher or}\\ \text{student teacher}\end{array}\right. \longleftrightarrow \left(\begin{array}{l}\text{understanding of}\\ \text{student learning}\\ \text{by teacher and}\\ \text{student}\end{array}\right)\Bigg]\Bigg\}$$

In other words, the most basic form of understanding is that of *student learning*. The nature and substance of this understanding will, however, change as we shift our attention from the students' understanding of their own learning to the teachers' understanding of student learning as reflected in their teaching practice, to the university educators' understanding of the teacher's practice **and** the way in which this practice influences student learning. The primary reason offered for these different types of *understandings* is that the purpose which they serve is quite different, as I endeavoured to illustrate in Figure 5.

I would now like to shift attention to the question posed earlier of whether it is possible to identify some underlying structure of beliefs and values which might be described in terms of a more generalized set of principles. Because we are concerned with collaborative relationships between people engaged in activities aimed at obtaining an improved understanding of learning and teaching, these principles will necessarily have both empirical and normative components. This is the case because our beliefs about teaching and learning are, in part, a product of our prior educational experiences and hence are shaped by our current understanding of how we, or others, learn something. This understanding is primarily empirical in nature and is continually being checked against the *reality* of classroom life to determine its viability. In accepting a description of this nature for the construction of knowledge about teaching and learning, we are also implicitly accepting a position that we ought to try and establish *learning conditions* which would enhance and nurture this construction process. Because we are dealing with human relationships in these endeavours, it is clear that in establishing an appropriate set of conditions we must invoke some set of normative or moral commitments.

In figure 6, I have attempted to reconstruct the most general empirical and normative propositions which appear to characterize the three levels of collaborative relationships as they have been operative in our project. Both the empirical and normative propositions can be derived from our commitment to a "constructivist perspective" on

Figure 6
PRINCIPLES OF COLLABORATIVE RELATIONSHIPS AIMED AT UNDERSTANDING AND IMPROVING LEARNING

Empirical Propositions

Learning often involves a process of inquiry into problematic situations.

- Therefore collaborative relationships must view teaching practice as being a form of reflective inquiry requiring both an *open* and a *critical* stance towards the problems of teaching.

Learning involves a process of continual growth.

- Therefore collaborative relationships must endeavour to promote a *disposition for reflective thought and behaviour.*

Learning is promoted when more responsibility and control (i.e. autonomy) is given to the learner.

- Therefore collaborative relationships must result in endeavours to *validate learners existing knowledge* and provide *opportunities for them to extend it.*

Normative Propositions

Teaching is a relationship involving mutual trust and inquiry.

- Therefore collaborative relationships must foster an atmosphere of *openess* and the *sharing of intentions and concerns*, while still promoting *critical comment.*

Teaching involves the taking of personal/professional risks.

- Therefore collaborative relationships must acknowledge the nature of these risks and attempt to establish some *degree of reciprocity* among the partners in terms of risk taking activities.

Teaching should display both personal and intellectual respect for the learners.

- Therefore collaborative relationships must be concerned with the *giving of reasons* for their actions.

learning (Driver and Oldham, 1986; von Glasersfeld, 1989). The empirical components focus primarily upon our *experiential model of learning* which draws extensively upon a type of neo-pragmatist account of knowledge construction such as that developed by Schön (1983, 1988) or Hirst (1983) in the context of professional knowledge. As such the notion of reflective inquiry into problematic situations is a very prominent feature of this position.

Other empirical commitments include the notion that the acquisition of knowledge is developmental in nature which implies that we are dealing with *lifelong learning* and hence our task is to try to develop dispositions which would enable this sort of learning to occur throughout a learners' (or teachers') life. Finally, our perspective also commits us to a view that we can promote learning by *validating the learners' existing knowledge* and encouraging them to take more responsibility and control over their own learning. I would argue that these are primarily empirical propositions because they are open to criticism and refinement on the basis of empirical evidence.

The other set of propositions listed in Figure 6 have been referred to as being primarily normative in nature since they entail a commitment to some form of moral principle guiding the conduct of the various collaborative relationships involved in the project. The first such proposition is the establishment of an atmosphere of mutual trust and openess that will permit individuals to voice their own intentions and concerns in teaching/learning situations. This proposition is related to the autonomy condition above in that we submit that it would be difficult for a learner to become more autonomous unless this kind of mutual trust is present in the collaborative relationship.

A second related proposition involves the importance of recognizing that teaching, or learning as it relates to personal growth, requires some degree of risk and that there should be some degree of reciprocal sharing of these risks in collaborative relationships.

A final proposition that we think is fundamental to our notion of collaborative relationships is the importance that we attach to *personal and intellectual respect* for the learner. Because we think of all the participants in our project as learners, this proposition applies to all three collaborative levels.

While I have not developed a detailed description of these propositions nor traced back the origins of each to our constructivist perspective, it would be relatively easy to do so. This task, however, must await another forum.

In conclusion, I have argued in this paper that because collaboration requires some form of working relationship toward a common goal or set of purposes, then the contexts in which these relationships occur and which determine the purposes of the activities are critical in determining the specific nature of any meaning that is attributed to this term. As such, I suggested that it may be futile to try to search for general, decontextualized descriptions of what a collaborative relationship might look like. This stance was not to deny the importance of obtaining some conceptual clarity for the use of these terms, but rather to examine the way in which the terms were used in a specific setting or project. A collaborative project with teachers, student teachers, and university educators directed towards the improvement of science learning was used as an example of such a specific setting. In analyzing the types of activities that we engaged in and the different types of understandings that we hoped to generate in the project, I claimed that one could differentiate between several types of collaborative relationships. Each of these types would likely lead to a different form of outcome. Furthermore, I argued that if one examined our underlying theoretical commitment to a "constructivist perspective" on learning, then it was possible to identify a number of general propositions or principles that appeared to guide many of our activities with the students as well as with the teachers involved in our project. These propositions, which are deeply embedded in the various activities and practices associated with our project, are, in my view, as close as we can come to articulating the meaning of a collaborative relationship.

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